



# Background

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## Chernobyl Nuclear Power Plant Accident

### Background

On April 26, 1986, an accident occurred at Unit 4 of the nuclear power station at Chernobyl, Ukraine, in the former USSR. The accident, caused by a sudden surge of power, destroyed the reactor and released massive amounts of radioactive material into the environment.

To stop the fire and prevent a criticality accident as well as any further substantial release of fission products, boron and sand were poured on the reactor from the air. In addition, the damaged unit was entombed in a temporary concrete "sarcophagus," to limit further release of radioactive material. Control measures to reduce radioactive contamination at and near the plant site included cutting down and burying a pine forest of approximately 1 square mile. The three other units of the four-unit Chernobyl nuclear power station were subsequently restarted. The Soviet nuclear power authorities presented an initial report on the accident at an International Atomic Energy Agency (IAEA) meeting in Vienna, Austria, in August 1986.

After the accident, access to the area in a 30-kilometer (18-mile) radius around the plant was closed, except for persons requiring official access to the plant and to the immediate area for evaluating and dealing with the consequences of the accident and operation of the undamaged units. The population evacuated from the most heavily contaminated areas numbered approximately 116,000 in 1986 and another 230,000 people in subsequent years (Source: UNSCEAR 2000, IAEA 2005).

Pripyat, the town near Chernobyl where most of the workers at the plant lived before the 1986 accident, was evacuated several days after the accident, because of radiological contamination. It was included in the 30-km Exclusion Zone around the plant and is closed to all but those with authorized access.

### Health Effects from the Accident

The Chernobyl accident caused many severe radiation effects almost immediately. Among the approximately 600 workers present on the site at the time of the accident, 2 died within hours of

the reactor explosion and 134 received high radiation doses and suffered from acute radiation sickness. Of these, twenty eight workers died in the first four months after the accident. Another 200,000 recovery workers involved in the initial cleanup work of 1986-1987 received doses of between 0.01 and 0.50 Gy. The number of workers involved in cleanup activities at Chernobyl rose to 600,000, although only a small fraction of these workers were exposed to dangerous levels of radiation. Both groups of cleanup and recovery workers may become ill because of their radiation exposure, so their health is being monitored.

The Chernobyl accident also resulted in widespread contamination in areas of Belarus, the Russian Federation, and Ukraine inhabited by millions of residents. Radiation exposure to residents evacuated from areas heavily contaminated by radioactive material from the Chernobyl accident also has been a concern. Average doses to Ukrainian and Belarusian evacuees were 17 mSv and 31 mSv, respectively. Individual exposures ranged from a low of 0.1 to 380 mSv. However, the majority of the five million residents living in contaminated areas received very small radiation doses which are comparable to natural background levels (1 mSv per year).

The health of these residents also has been monitored since 1986, and to date there is no strong evidence for radiation-induced increases of leukemia or solid cancer (other than thyroid cancer). An exception is a large number of children and adolescents who in 1986 received substantial radiation doses in the thyroid after drinking milk contaminated with radioactive iodine. To date, about 4,000 thyroid cancer cases have been detected among these children. Although 99% of these children were successfully treated, nine children and adolescents in the three countries died from thyroid cancer. Fortunately, no evidence of any effect on the number of adverse pregnancy outcomes, delivery complications, stillbirths or overall health of children has been observed among the families living in the most contaminated areas.

Apart from the increase in thyroid cancer after childhood exposure, no increase in overall cancer or non-cancer diseases have been observed that can be attributed to the Chernobyl accident and exposure to radiation. However, it is estimated that approximately 4,000 radiation-related cancer deaths may eventually be attributed to the Chernobyl accident over the lifetime of the 200,000 emergency workers, 116,000 evacuees, and 270,000 residents living in the most contaminated areas. This estimate is far lower than initial speculations that radiation exposure would claim tens of thousands of lives, but it is not greatly different from estimates made in 1986 by Soviet scientists.

## **US Reactors and NRC's Response**

U.S. reactors have different plant designs, broader shutdown margins, robust containment structures, and operational controls to protect them against the combination of lapses that led to the accident at Chernobyl. Although the NRC has always acknowledged the possibility of major accidents, its regulatory requirements provide adequate protection, subject to continuing vigilance, including review of new information that may suggest weaknesses.

Assessments in the light of Chernobyl have indicated that the causes of the accident have been

adequately dealt within the design of U.S. commercial reactors. However, the Chernobyl accident emphasized the importance of safe design in both concept and implementation, of operational controls, of competence and motivation of plant management and operating staff to operate in strict compliance with controls, and of backup features of defense-in-depth against potential accidents.

Although a large nuclear power plant accident somewhere in the United States is unlikely because of design and operational features, the assessment of Chernobyl raised questions as to whether changes were needed to NRC regulations or guidance regarding reactivity accidents, accidents at low or zero power, operator training, and emergency planning.

The NRC's response to the Chernobyl accident was divided into three major phases: (1) determining the facts of the accident, (2) assessing the implications of the accident for safety regulation of commercial nuclear power plants in the United States, and (3) conducting additional specific studies suggested by the assessment.

The first phase, fact finding, was a coordinated effort between several U.S. government agencies and some private groups, with the NRC acting as the coordinating agency. The work was completed in January 1987 and reported in NUREG-1250, "Report on the Accident at the Chernobyl Nuclear Power Station."

The second phase, the implications study, was reported in NUREG-1251, "Implications of the Accident at Chernobyl for Safety Regulation of Commercial Nuclear Power Plants in the United States," issued in April 1989. The report concluded that no immediate changes were needed in the NRC's regulations regarding the design or operation of U.S. commercial nuclear reactors as a result of lessons learned from Chernobyl.

For the third phase, Chernobyl follow-up studies for U.S. reactors were reported in June 1992 in NUREG-1422, "Summary of Chernobyl Follow-up Research Activities." That report closed out the Chernobyl follow-up research program, though certain issues will continue to receive attention in the normal course of NRC work. For example, the NRC will follow long-term lessons with regard to contamination control -- decontamination, ingestion pathway, relocation of people. The NRC recognizes that the Chernobyl experience should remain a valuable part of the information to be taken into account when dealing with reactor safety issues in the future.

## **Discussion**

The Chernobyl reactors are of the RBMK type. These are high-power, pressure-tube reactors, moderated with graphite and cooled with water. At the time of the Chernobyl accident there were 17 RBMKs in operation in the Soviet Union and two in Lithuania. Since the accident, five RBMKs have been shut down. All four units at Chernobyl and one of the Lithuanian RBMKs were shut down.

At Chernobyl:

- Unit 4 reactor was destroyed in the 1986 accident;

- Unit 2 was shut down five years later; after a serious turbine building fire;
- Unit 1 was closed in November 1996, and
- Unit 3 was closed December 15, 1999, as promised by Ukrainian President Leonid Kuchma.

In Lithuania, Ignalina Unit 1 was shut down in December 2004 as a condition of admission to the European Union. Of the remaining 12 operating RBMKs, 11 are in Russia and one is in Lithuania (proposed to be decommissioned by 2009).

The countries of the G-7, the European Commission and Ukraine helped in closing these reactors. This effort included support for such things as Chernobyl Unit 3 plant-specific short-term safety upgrades, decommissioning of the Chernobyl Nuclear Power Plant, development of an action plan for addressing the social impacts on workers and their families resulting from Chernobyl closure, and identification of power supply investments needed to meet Ukraine's future electrical power needs.

On April 26, 1996, the tenth anniversary of the Chernobyl accident, Ukrainian President Kuchma formally established the Chernobyl Center for Nuclear Safety, Radioactive Waste and Radioecology in the town of Slavutych. The Center would provide the Ukraine with an indigenous, institutional capability to provide technical support to its nuclear power industry, the academic community, and nuclear regulators.

### Sarcophagus

Construction of the sarcophagus covering the destroyed Chernobyl Unit 4 was started in May 1986 and completed by the Soviet authorities in an extremely challenging environment six months later in November. It was quickly built as a temporary fix to channel remaining radiation from the reactor through air filters before being released to the environment. After several years, uncertainties about the actual condition of the sarcophagus, primarily due to the high radiation environment, began to emerge.

In 1997, the countries of the G-7, the European Commission and Ukraine agreed that a multilateral funding mechanism be established to help Ukraine transform the existing sarcophagus into a stable and environmentally safe system through the Chernobyl Shelter Implementation Plan. The Chernobyl Shelter Fund was established to finance the Plan. The European Bank for Reconstruction and Development was entrusted with managing the Fund. The Plan is intended to protect the personnel, population and environment from the threat of the very large inventory of radioactive material contained within the existing sarcophagus for many decades. First, the existing sarcophagus will be stabilized and then eventually it will be replaced with a new safe shelter (confinement). New shelter construction is expected to start in late 2006 with a design to include an arch-shaped steel structure, which will slide across the existing sarcophagus via rails. This new structure is designed to remain functional for 100 years.

### **Information Resources**

UNSCEAR 1988 Report, Sources, Effects and Risks of Ionizing Radiation  
Annex D, Exposures from the Chernobyl accident.

<http://www.unscear.org/docs/reports/1988annexd.pdf>

UNSCEAR 1988 Report, Sources, Effects and Risks of Ionizing Radiation  
Appendix to Annex G, Early effects in man of high radiation doses.

<http://www.unscear.org/docs/reports/1988annexgappx.pdf>

UNSCEAR 2000 Report, Sources and Effects of Ionizing Radiation  
Annex J, Exposures and effects of the Chernobyl accident.

<http://www.unscear.org/docs/reports/annexj.pdf>

Environmental Consequences of the Chernobyl Accident and Their Remediation: Twenty years  
of Experience, Report of the UN Chernobyl Forum Expert Group “Environment,” August 2005

<http://www.iaea.org/>

Health Effects of the Chernobyl Accident and Special Health care Programmes, Report of the  
UN Chernobyl Forum Expert Group on “Health,” Geneva 2006

[http://www.who.int/ionizing\\_radiation/chernobyl/who\\_chernobyl\\_report\\_2006.pdf](http://www.who.int/ionizing_radiation/chernobyl/who_chernobyl_report_2006.pdf)

Chernobyl’s Legacy: Health, Environmental and Socio-Economic Impacts and  
Recommendations to the Governments of Belarus, the Russian Federation and Ukraine, The  
Chernobyl Forum: 2003-2005, September 2005.

<http://www.iaea.org/>

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